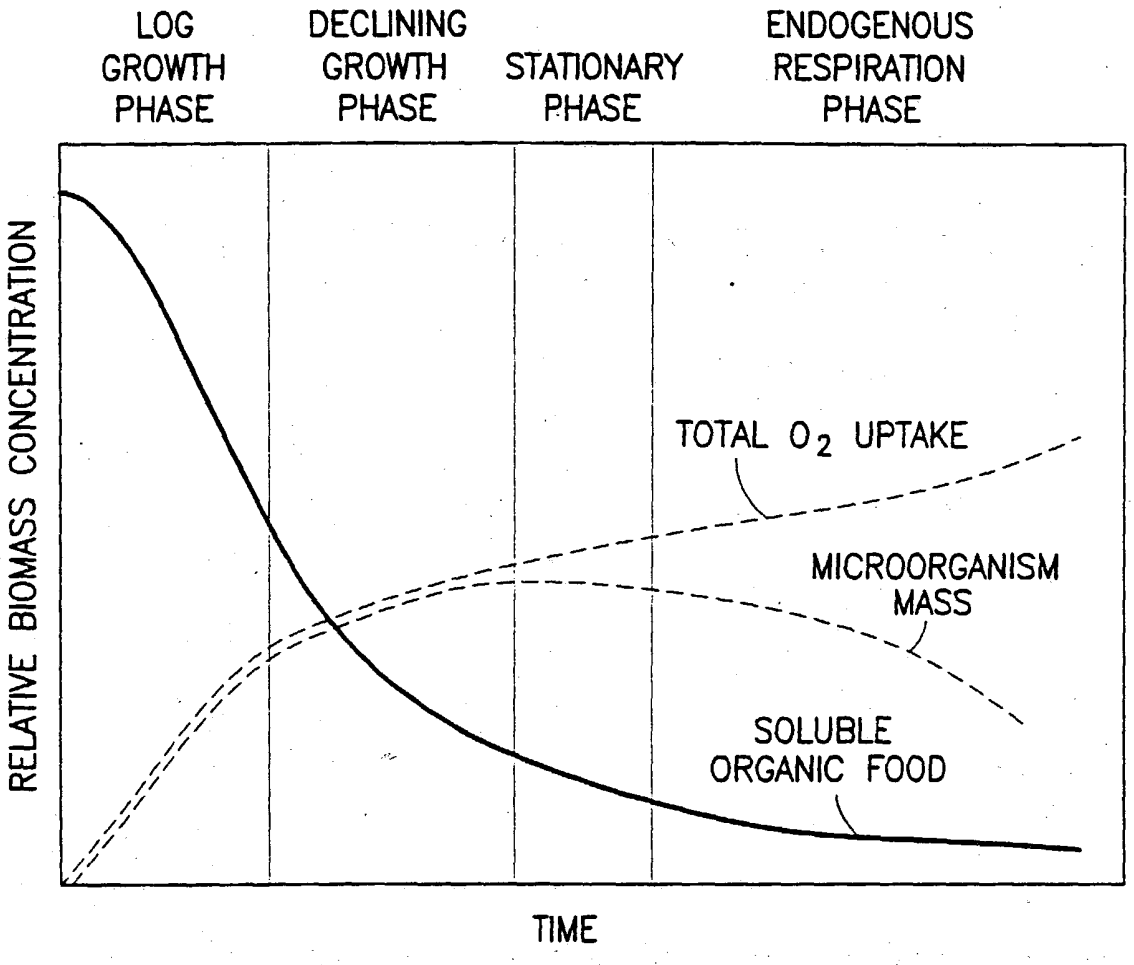

LOG GROWTH PHASE
DECLINING GROWTH PHASE
STATIONARY PHASE
ENDOGENOUS RESPIRATION PHASE
RELATIVE BIOMASS CONCENTRATION
TOTAL $O_2$ UPTAKE
MICROORGANISM MASS
SOLUBLE ORGANIC FOOD
TIME

FIG.1

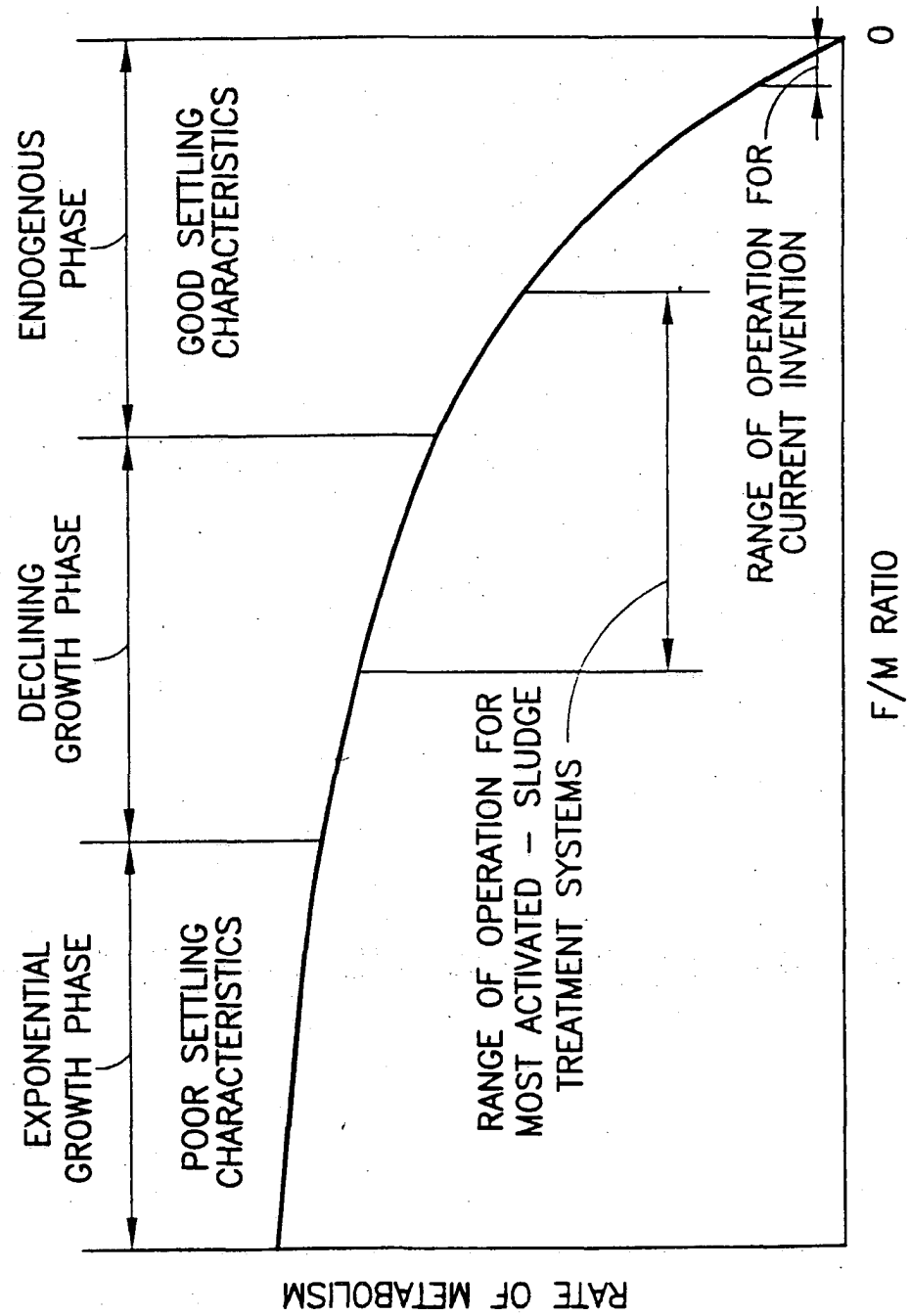

RATE OF METABOLISM
F/M RATIO
0
ENDOGENOUS PHASE
DECLINING GROWTH PHASE
EXPONENTIAL GROWTH PHASE
GOOD SETTLING CHARACTERISTICS
POOR SETTLING CHARACTERISTICS
RANGE OF OPERATION FOR MOST ACTIVATED – SLUDGE TREATMENT SYSTEMS
RANGE OF OPERATION FOR CURRENT INVENTION

FIG.2

| | PRESENT INVENTION | COMPLETE MIX | PLUG FLOW | CONTACT STABILIZATION | STEP FEED | EXTENDED AERATION |
|---|---|---|---|---|---|---|
| AERATION TIME (hrs) | 4–8 | 3–5 | 4–8 | .5–1.0 | 3–5 | 18–36 |
| MCRT (days) | 30–>150 | 15–30 | 15–30 | 5–15 | 5–15 | 15–30 |
| F/M RATIO (lbs BOD/day/lb MLVSS) | 0.05–0.80 | 0.05–0.20 | 0.05–0.20 | 0.20–0.40 | 0.20–0.4 | 0.05–0.2 |
| MLSS | 2,000–10,000 | 3,000–6,000 | 1,500–3,000 | 1,000–3,000 | 2,000–3,500 | 3,000–6,000 |
| RAS RECIRCULATION % RAS/(Q) | 25–100 | 25–100 | 25–50 | 25–100 | 25–75 | 75–150 |
| PROCESSING RECIRCULATION % | 500–2000 | N/A | N/A | N/A | N/A | N/A |

WASTEWATER TREATMENT SYSTEMS COMPARATIVE

FIG.3

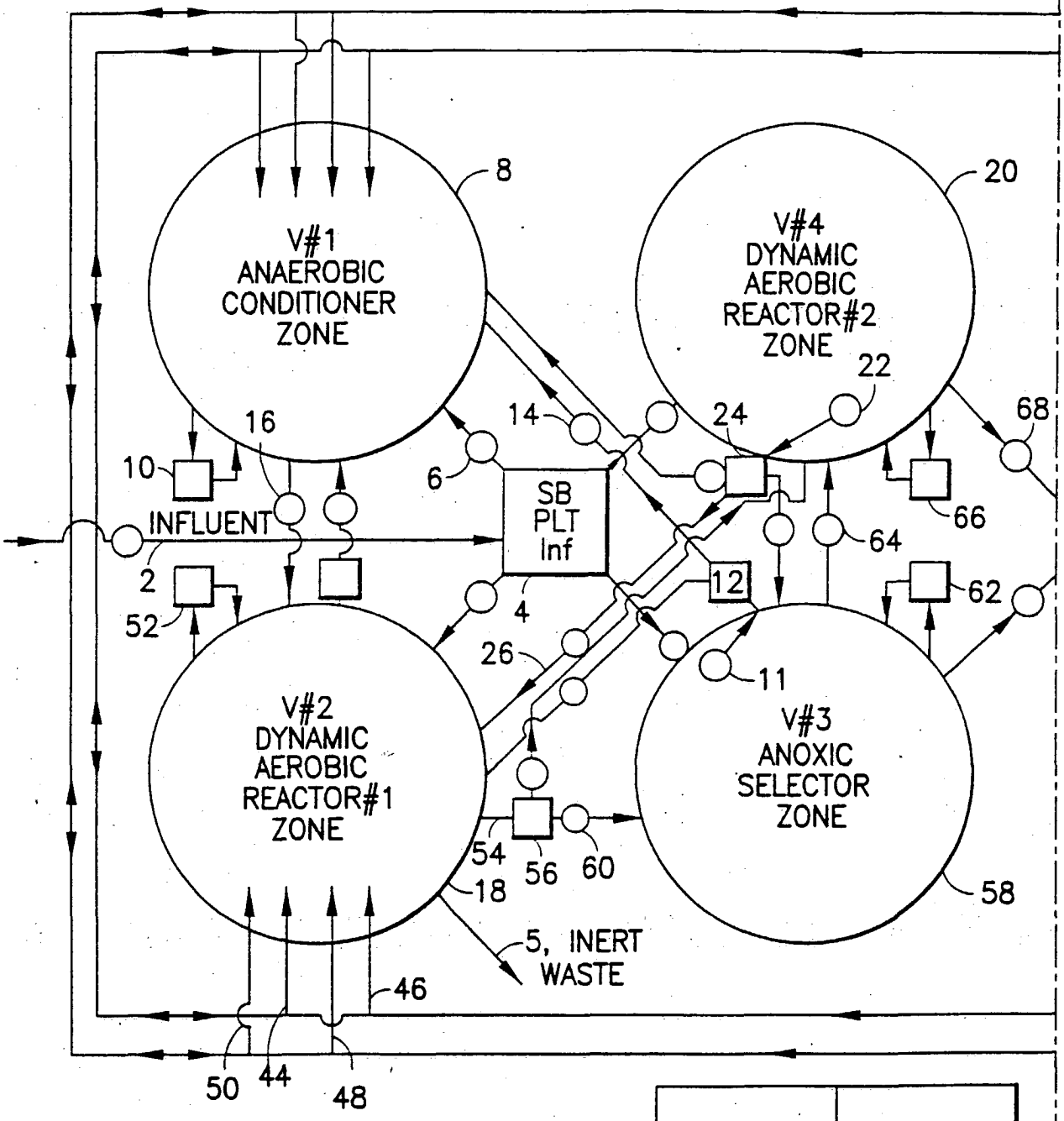



FIG.4A

FIG.4A | FIG.4B

FIG.4

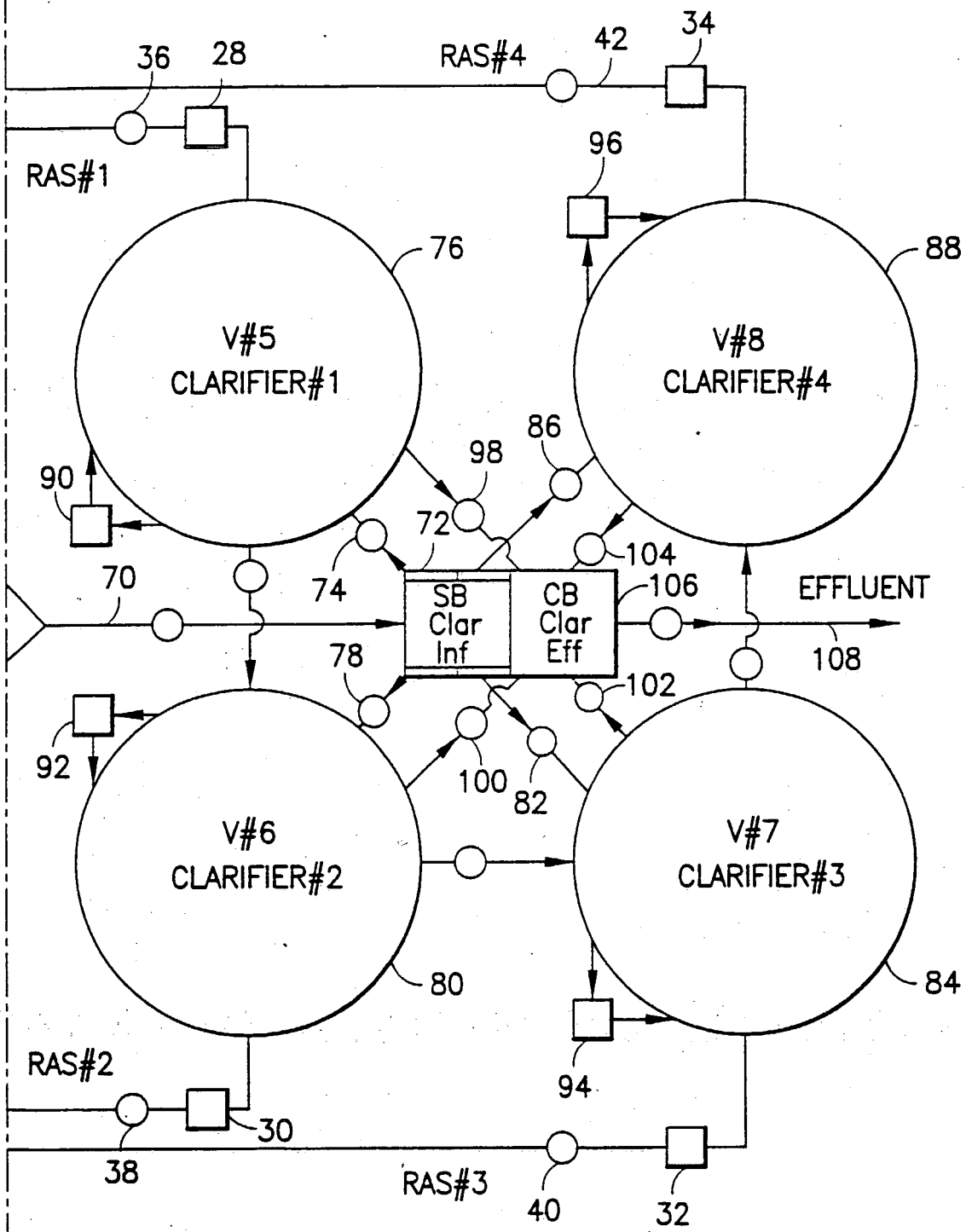

36
28
RAS#4
42
34
RAS#1
96
76
88
V#5
CLARIFIER#1
V#8
CLARIFIER#4
86
98
90
72
104
70
74
SB
Clar
Inf
CB
Clar
Eff
106
EFFLUENT
78
108
102
92
100
82
V#6
CLARIFIER#2
V#7
CLARIFIER#3
80
84
RAS#2
94
30
38
RAS#3
40
32

FIG.4B

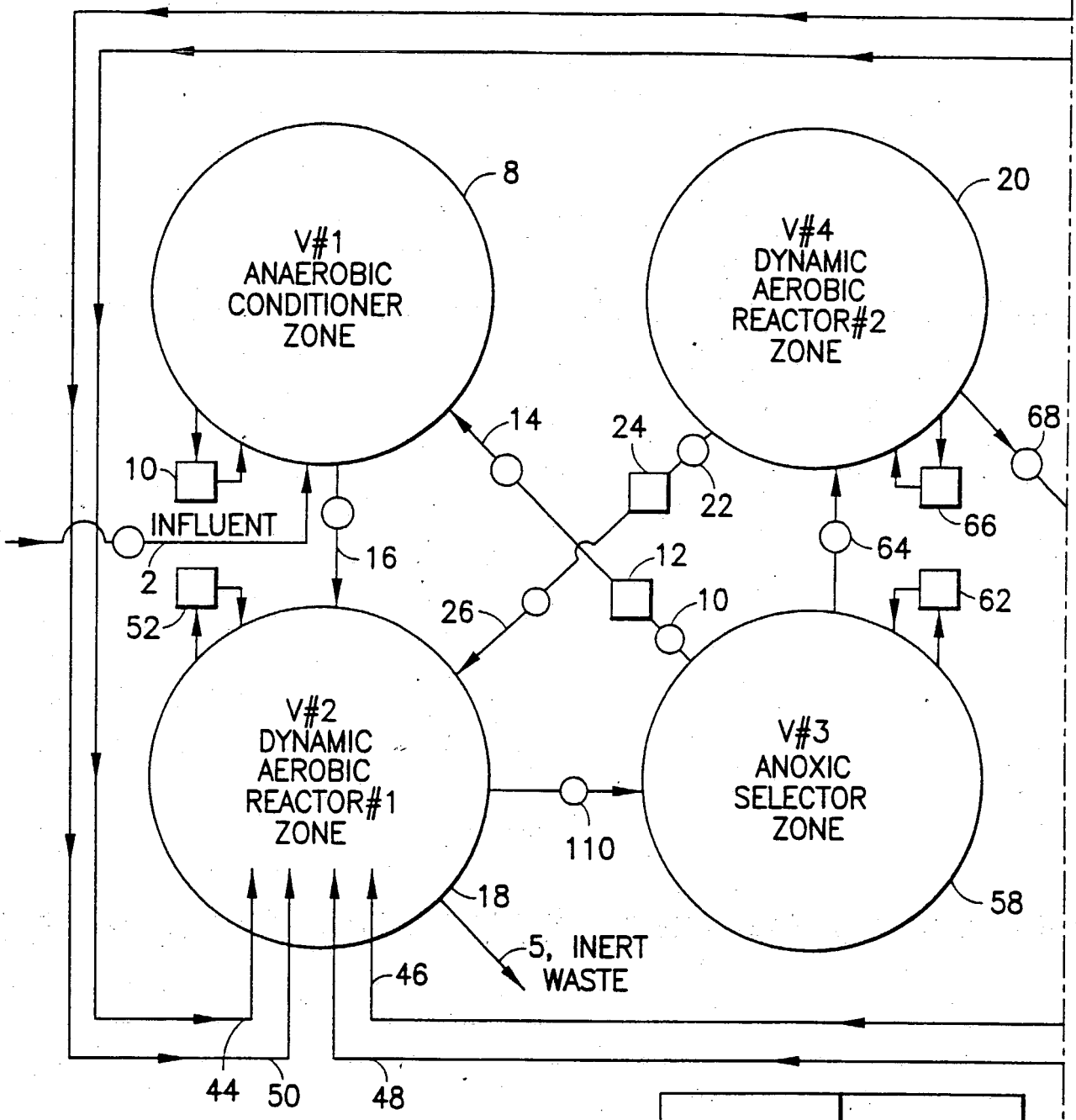



FIG.5A

FIG.5A | FIG.5B

FIG.5

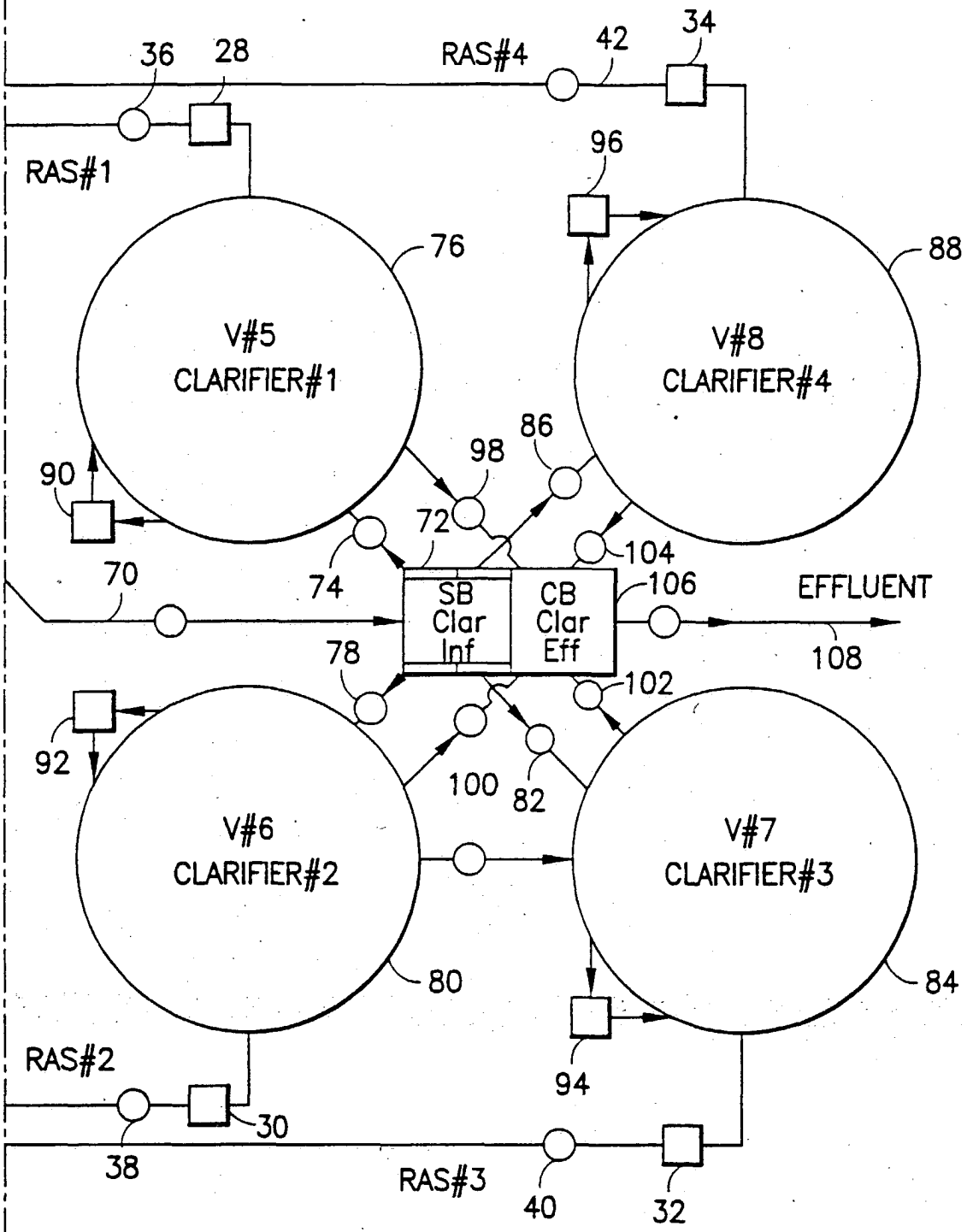

36
28
RAS#4
42
34
RAS#1
96
76
88
V#5
CLARIFIER#1
V#8
CLARIFIER#4
86
98
90
72
104
74
70
SB
Clar
Inf
CB
Clar
Eff
106
EFFLUENT
78
108
102
92
100
82
V#6
CLARIFIER#2
V#7
CLARIFIER#3
80
84
RAS#2
94
30
38
RAS#3
40
32

FIG.5B

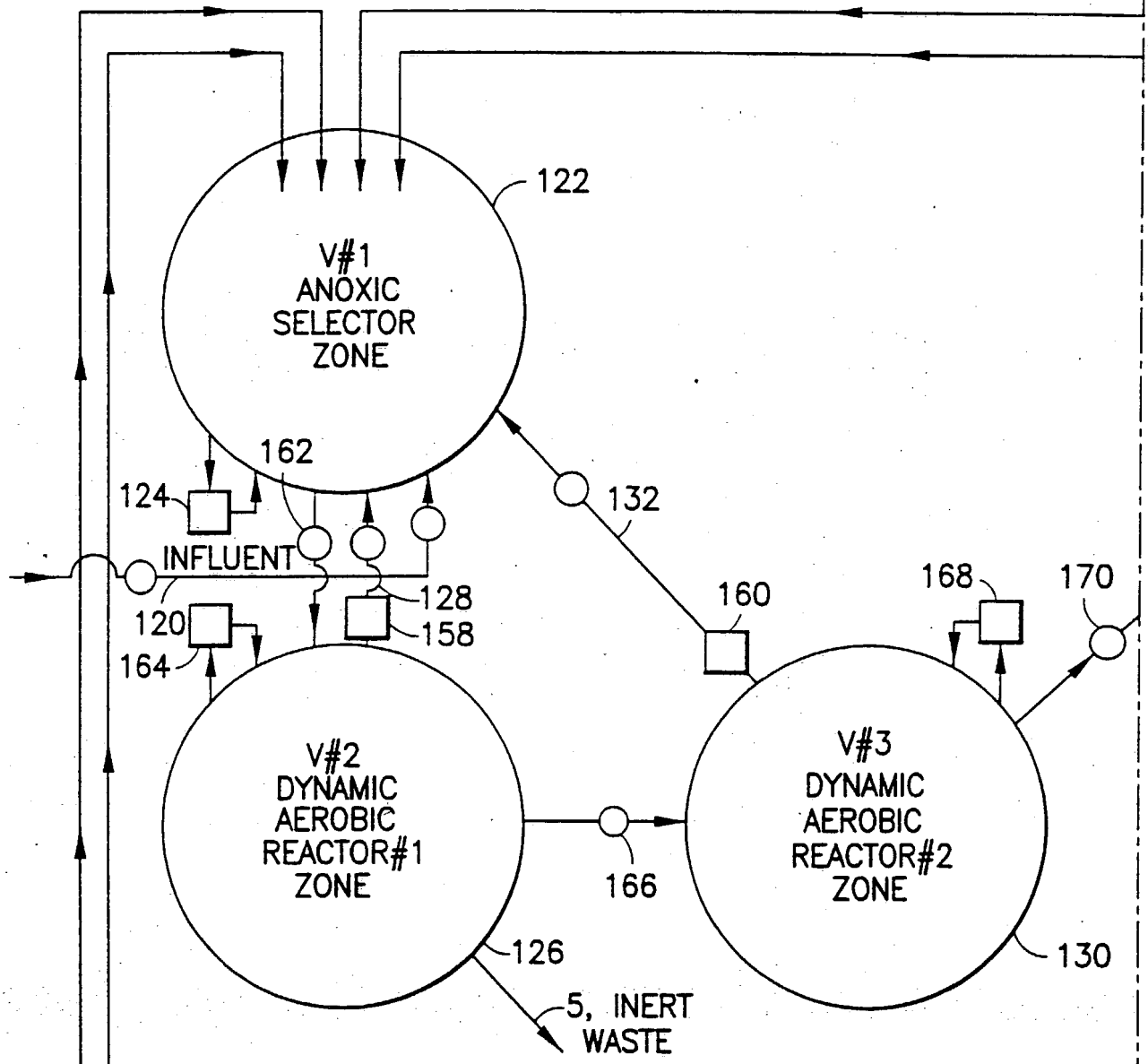



FIG.6A FIG.6B

FIG.6

FIG.6A

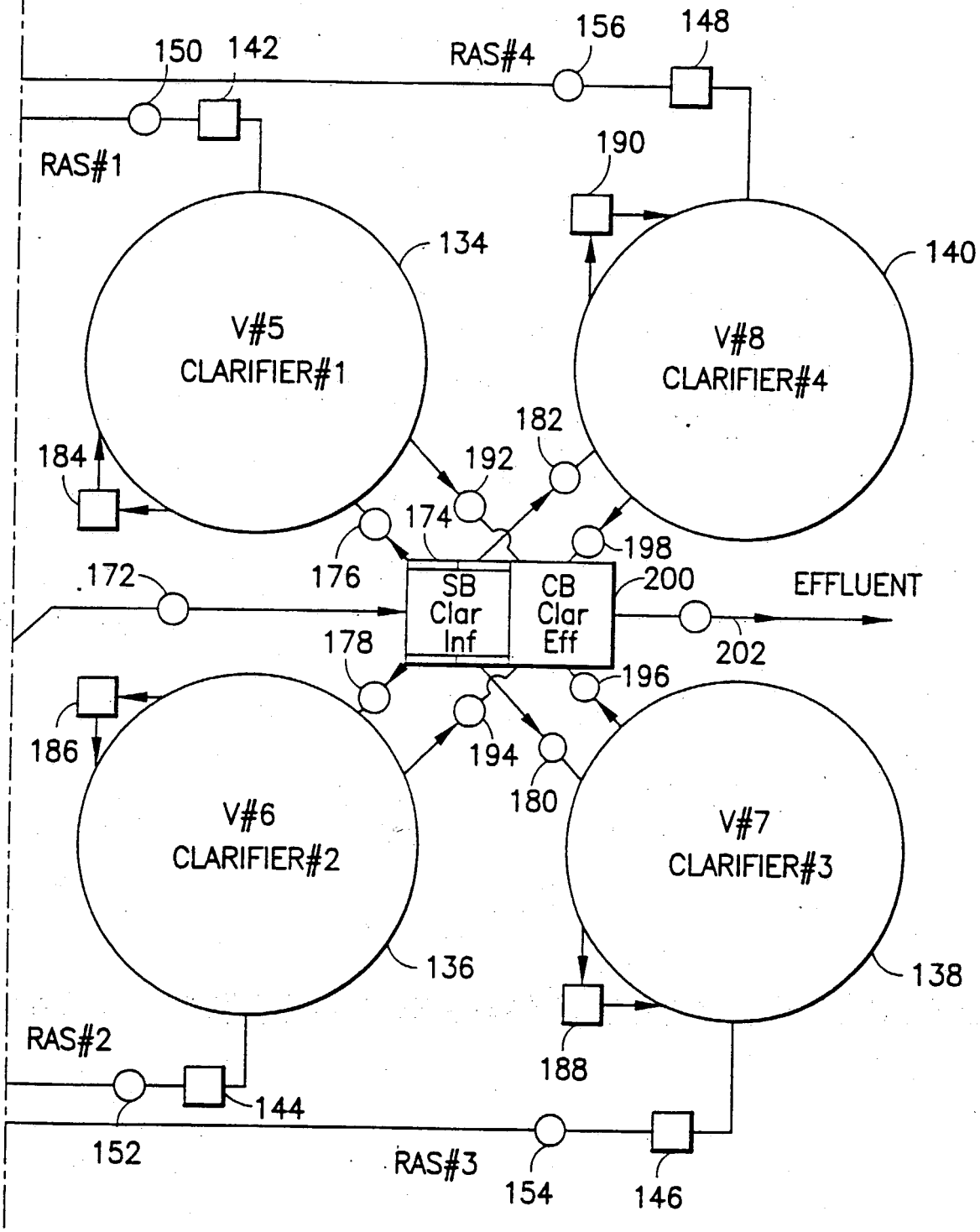
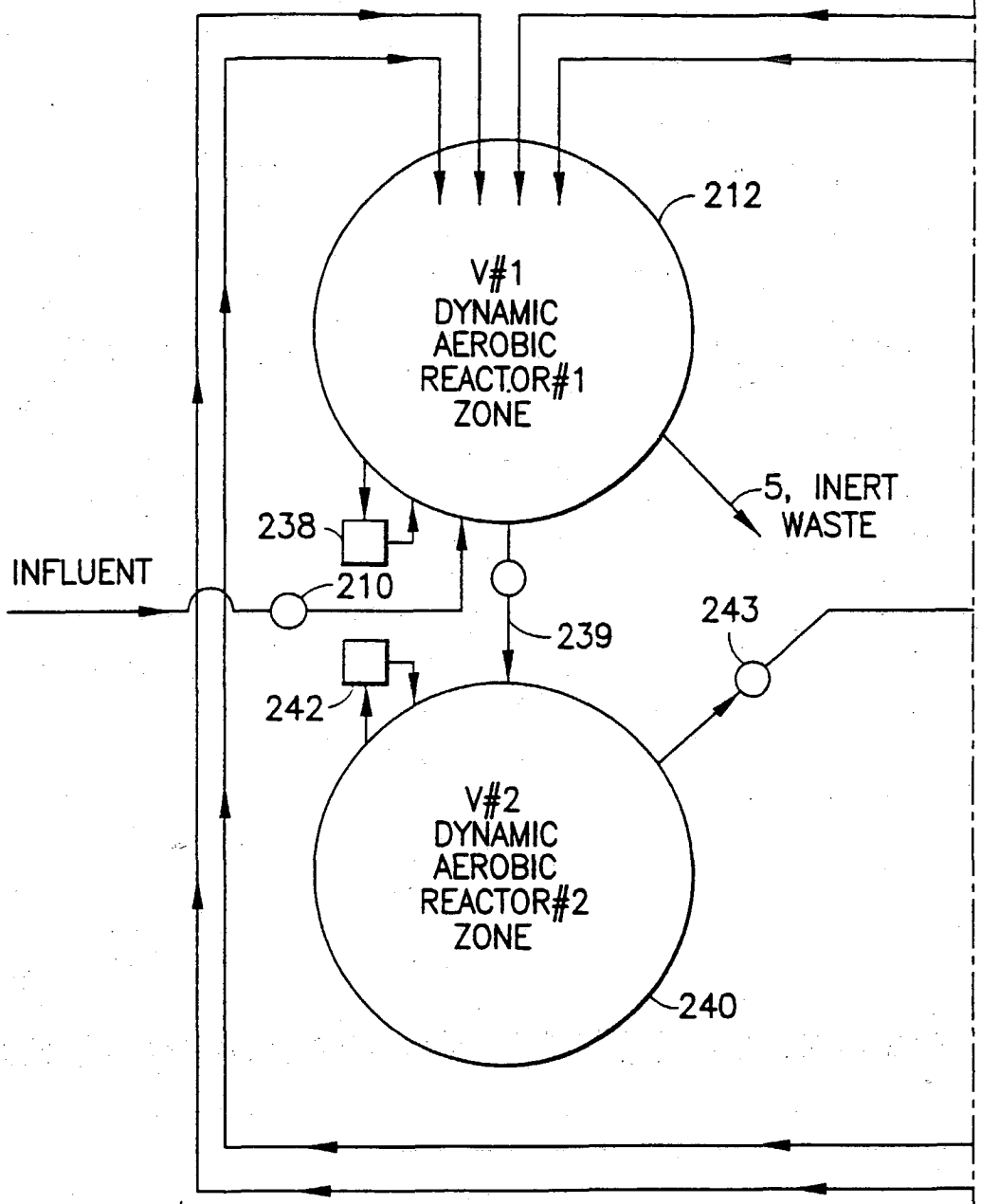

150
142
RAS#4
156
148
RAS#1
190
134
140
V#5
CLARIFIER#1
V#8
CLARIFIER#4
182
184
192
174
176
198
172
SB
Clar
Inf
CB
Clar
Eff
200
EFFLUENT
178
202
196
186
194
180
V#6
CLARIFIER#2
V#7
CLARIFIER#3
136
138
188
RAS#2
144
152
RAS#3
154
146

FIG.6B




| FIG.7A | FIG.7B |
|---|---|

FIG.7

FIG.7A

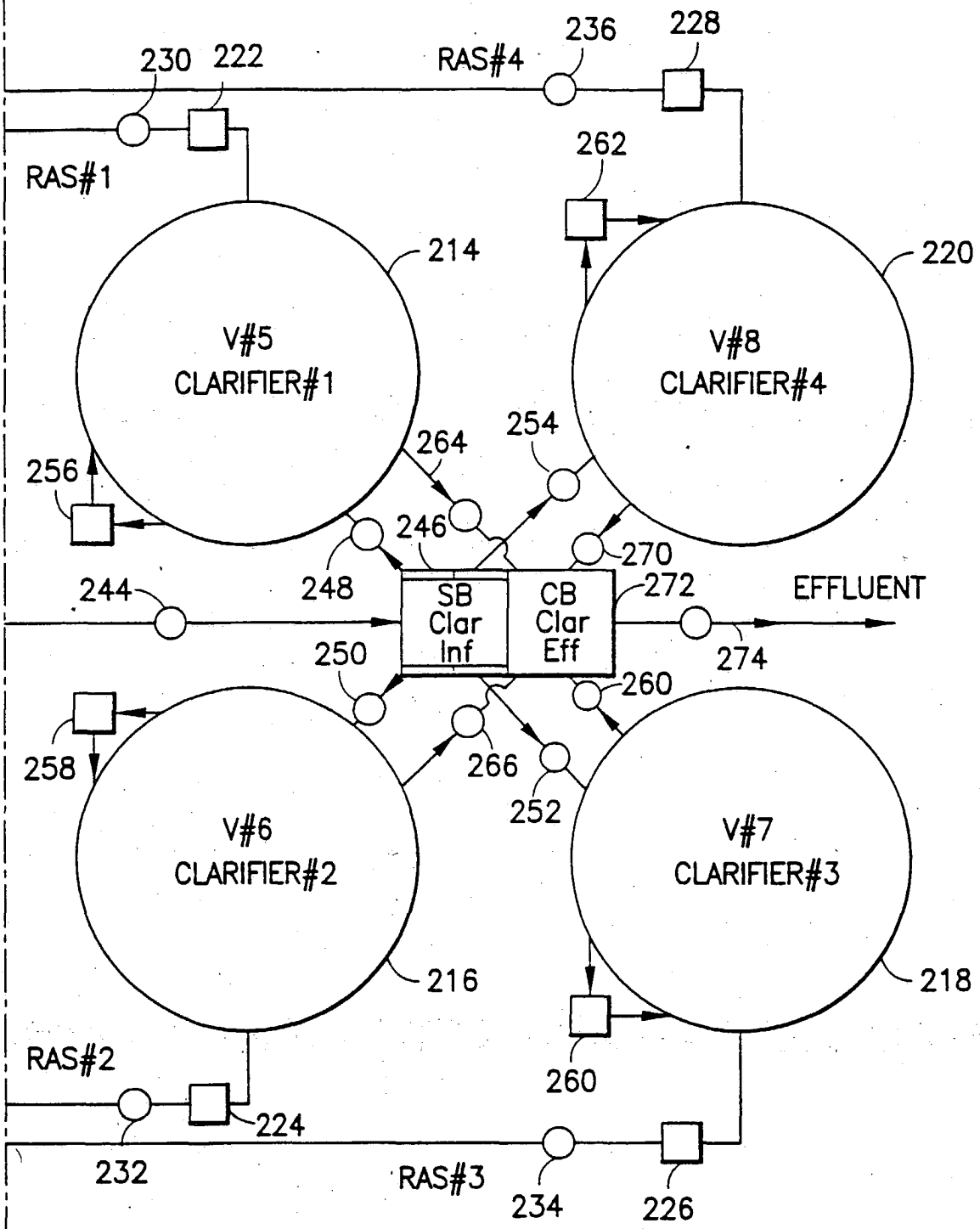

230
222
RAS#4
236
228
RAS#1
262
214
220
V#5
CLARIFIER#1
V#8
CLARIFIER#4
254
264
256
246
270
248
244
SB
Clar
Inf
CB
Clar
Eff
272
EFFLUENT
250
274
260
258
266
252
V#6
CLARIFIER#2
V#7
CLARIFIER#3
216
218
260
RAS#2
224
232
RAS#3
234
226

FIG.7B

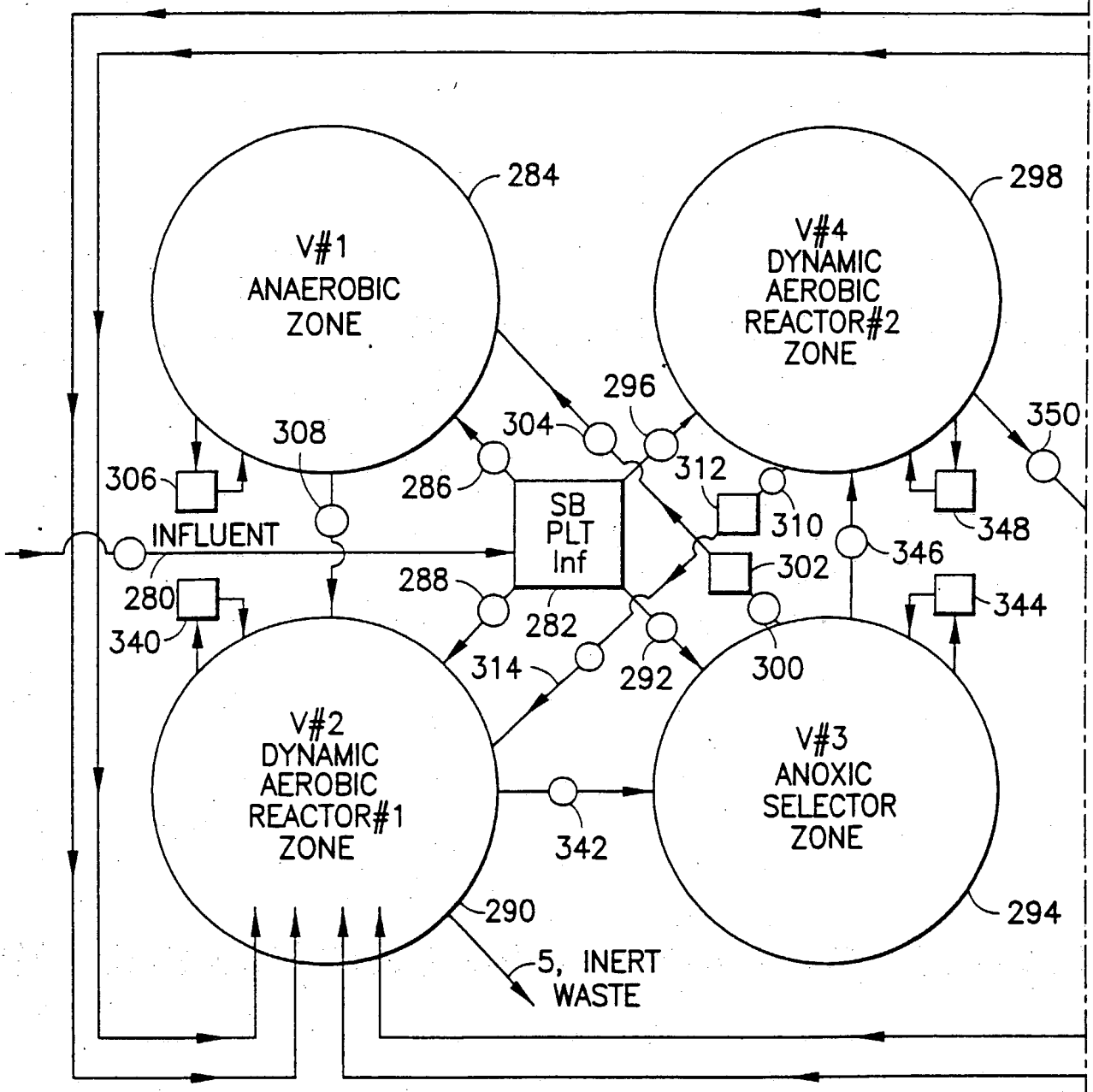



FIG.8A

FIG.8A | FIG.8B

FIG.8

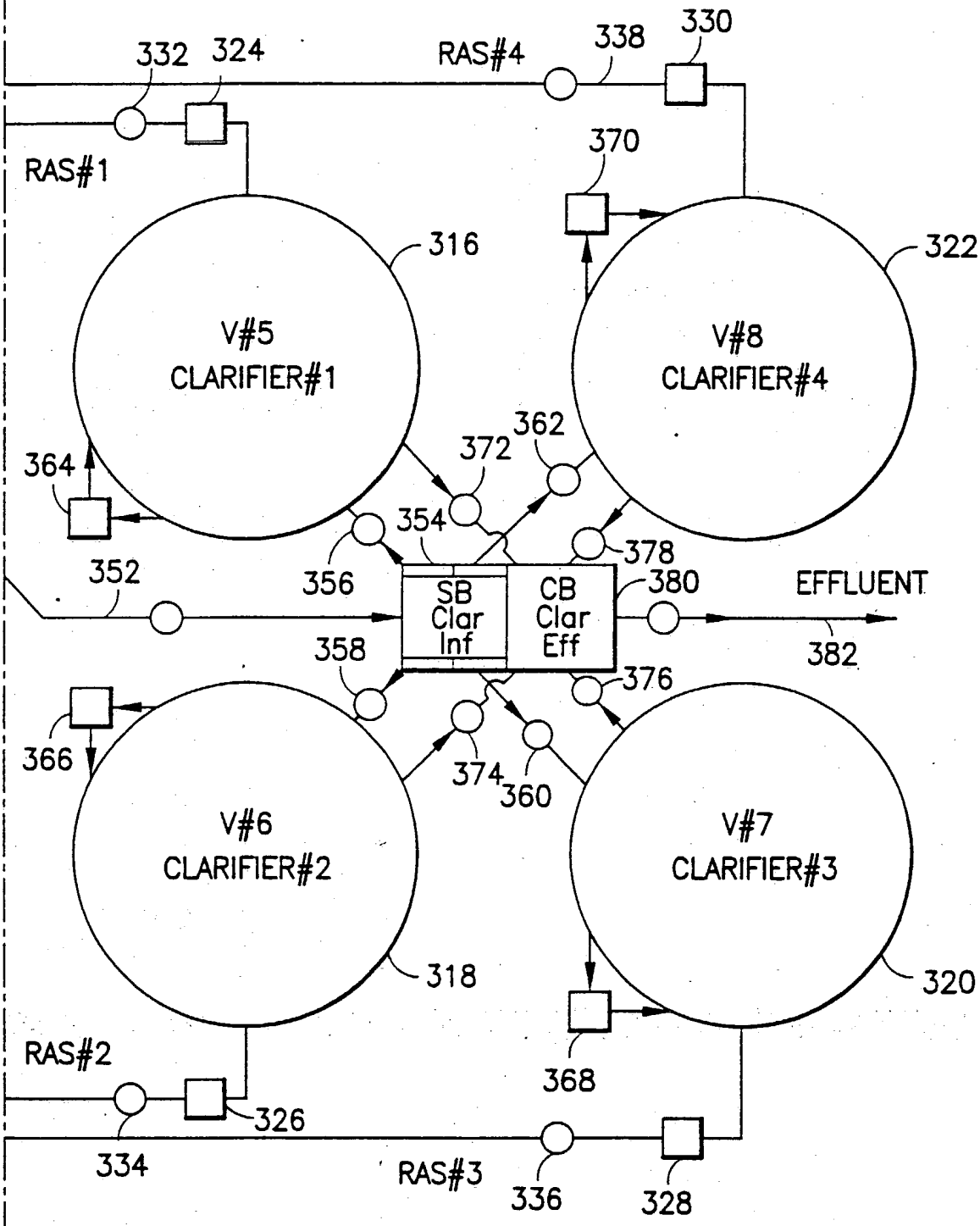

332
324
RAS#4
338
330
RAS#1
370
316
322
V#5
CLARIFIER#1
V#8
CLARIFIER#4
362
372
364
354
378
352
356
SB
Clar
Inf
CB
Clar
Eff
380
EFFLUENT
382
358
376
366
374
360
V#6
CLARIFIER#2
V#7
CLARIFIER#3
318
320
RAS#2
368
326
334
RAS#3
336
328

FIG.8B

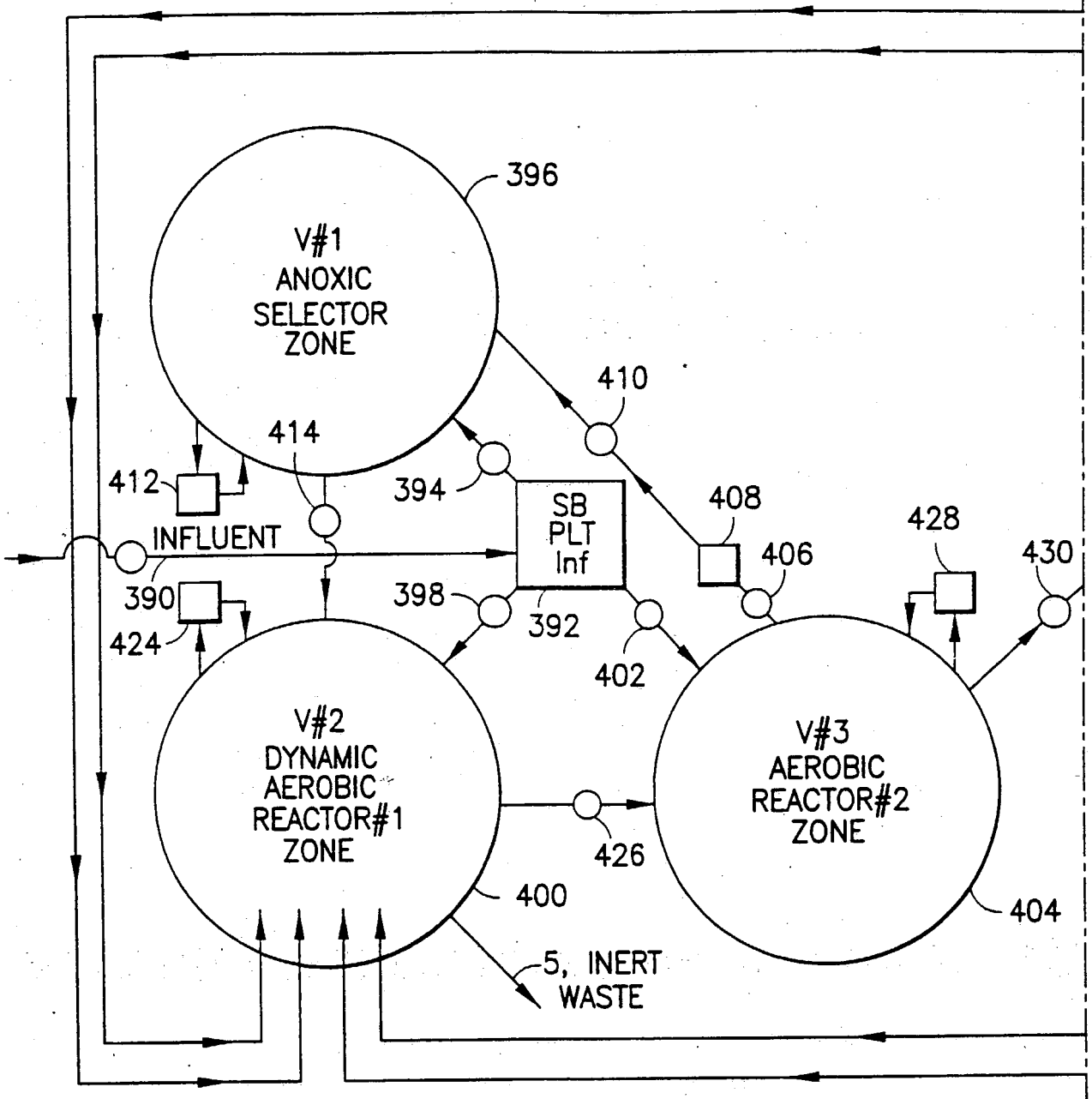



FIG.9A

FIG.9A | FIG.9B

FIG.9

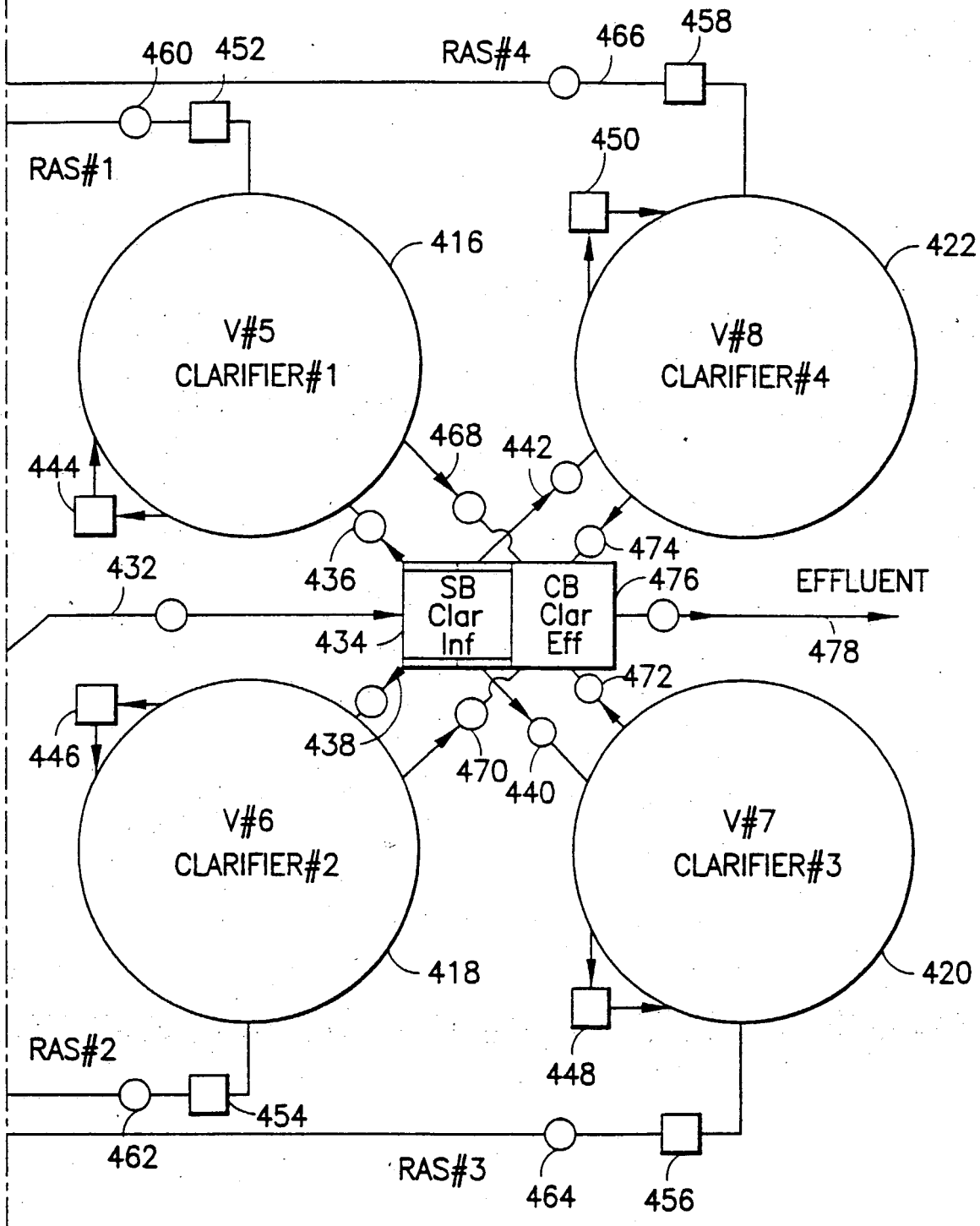

460
452
RAS#4
466
458
RAS#1
450
416
422
V#5
CLARIFIER#1
V#8
CLARIFIER#4
468
442
444
474
432
436
SB
Clar
Inf
CB
Clar
Eff
476
EFFLUENT
434
478
472
446
438
470
440
V#6
CLARIFIER#2
V#7
CLARIFIER#3
418
420
448
RAS#2
454
462
RAS#3
464
456

FIG.9B

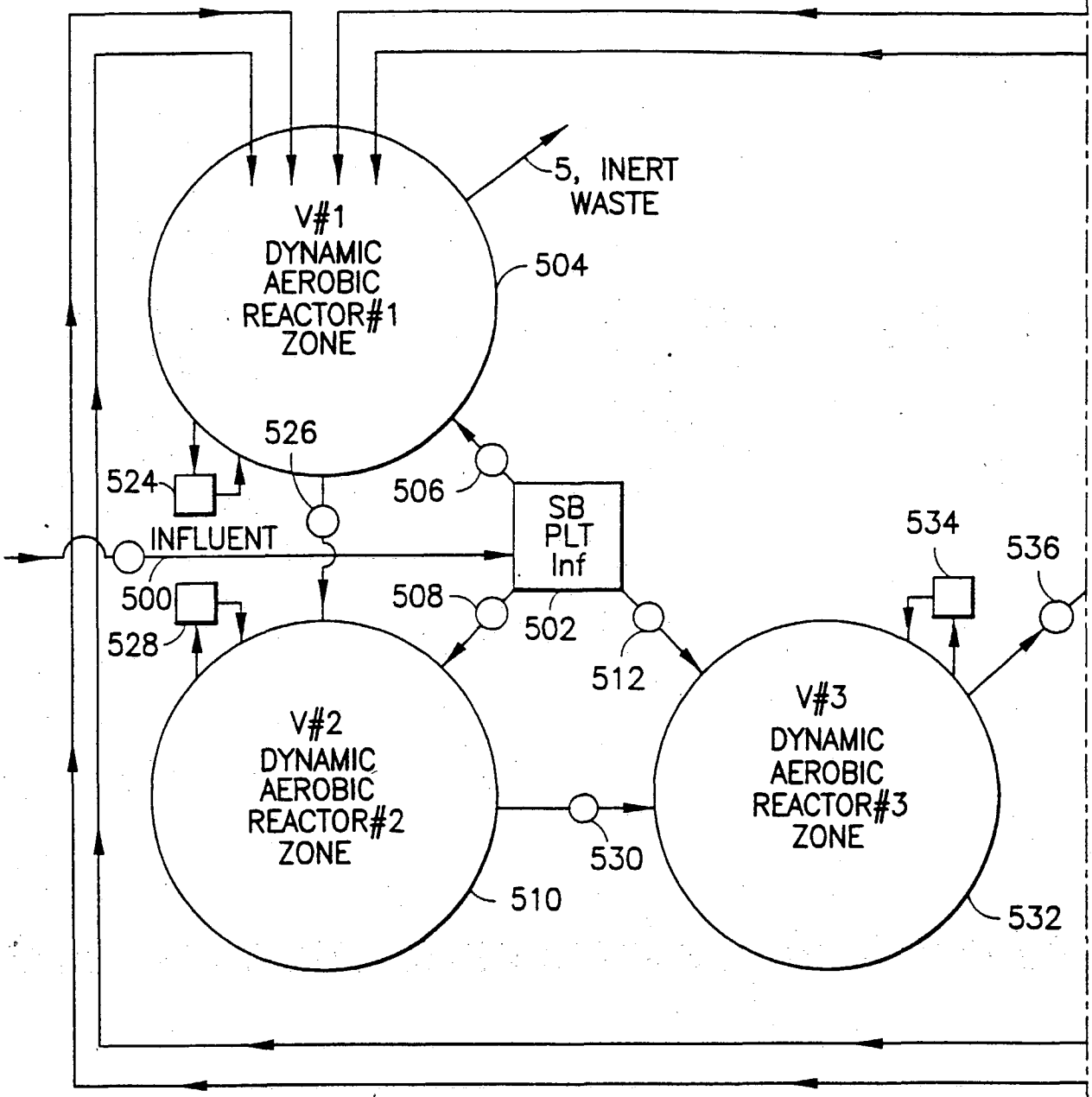



FIG.10A FIG.10B

FIG.10

FIG.10A

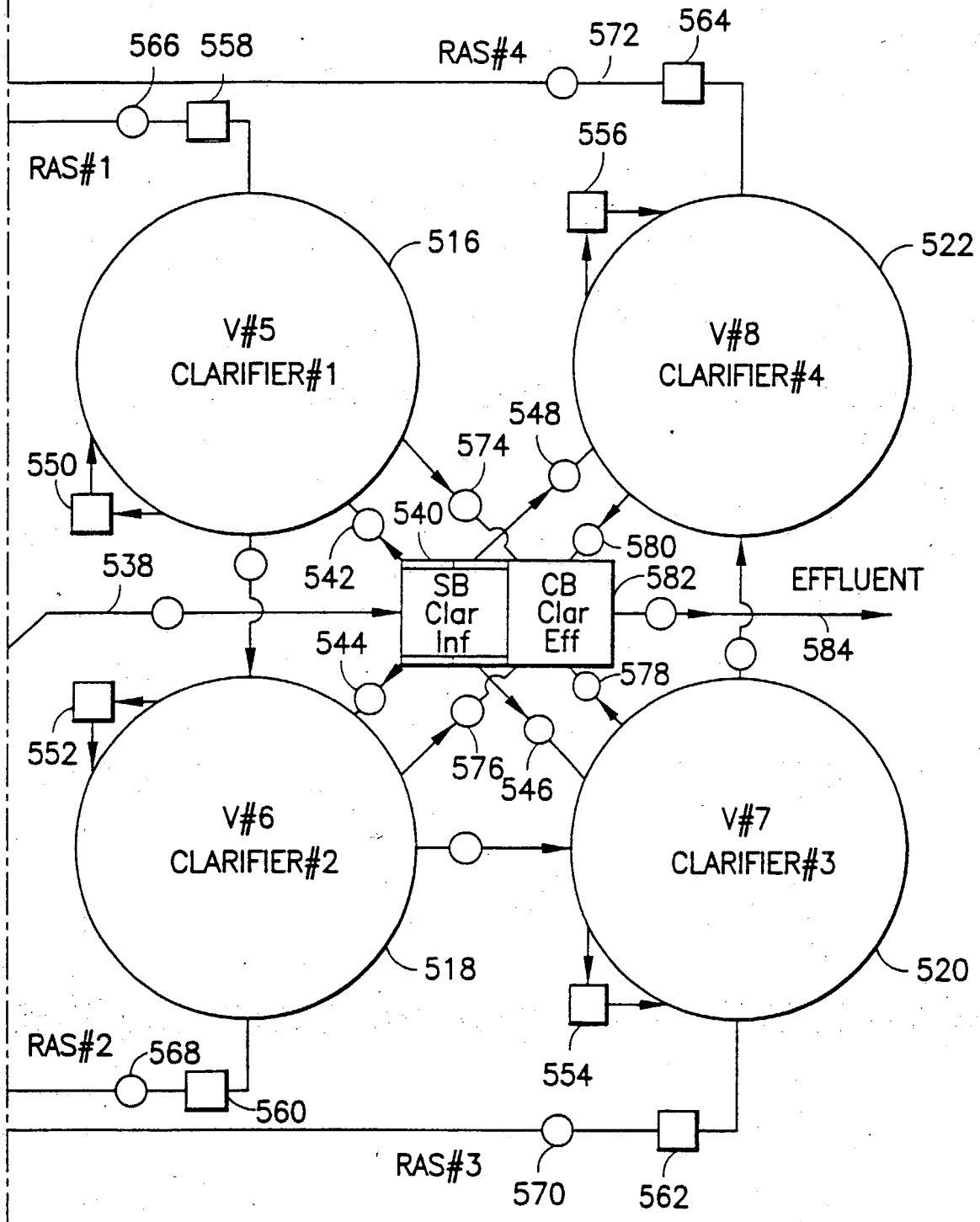

566
558
RAS#4
572
564
RAS#1
556
516
522
V#5
CLARIFIER#1
V#8
CLARIFIER#4
548
574
550
540
580
538
542
SB
Clar
Inf
CB
Clar
Eff
582
EFFLUENT
544
584
578
552
576
546
V#6
CLARIFIER#2
V#7
CLARIFIER#3
518
520
RAS#2
568
554
560
RAS#3
570
562

FIG.10B

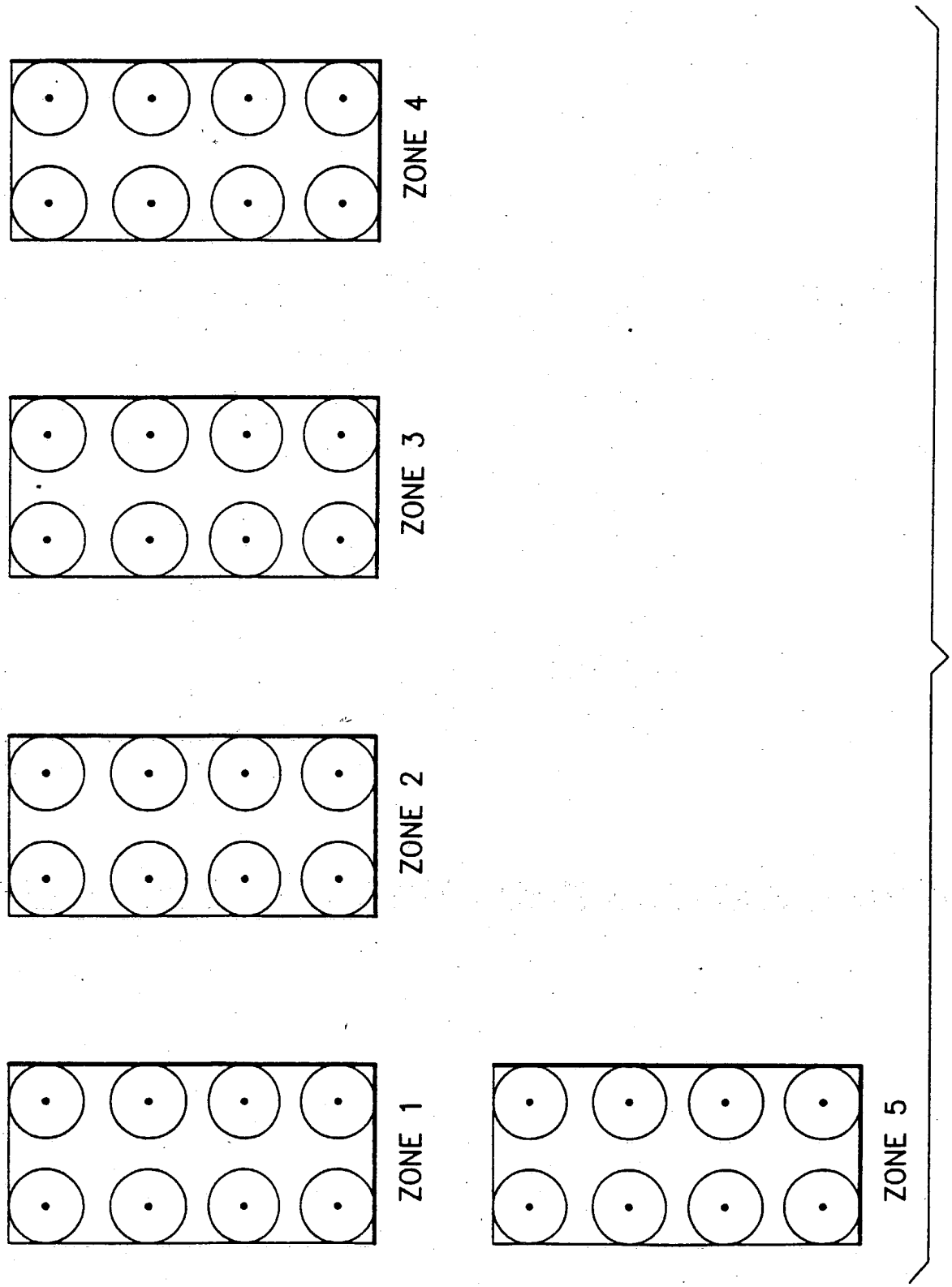



FIG.11

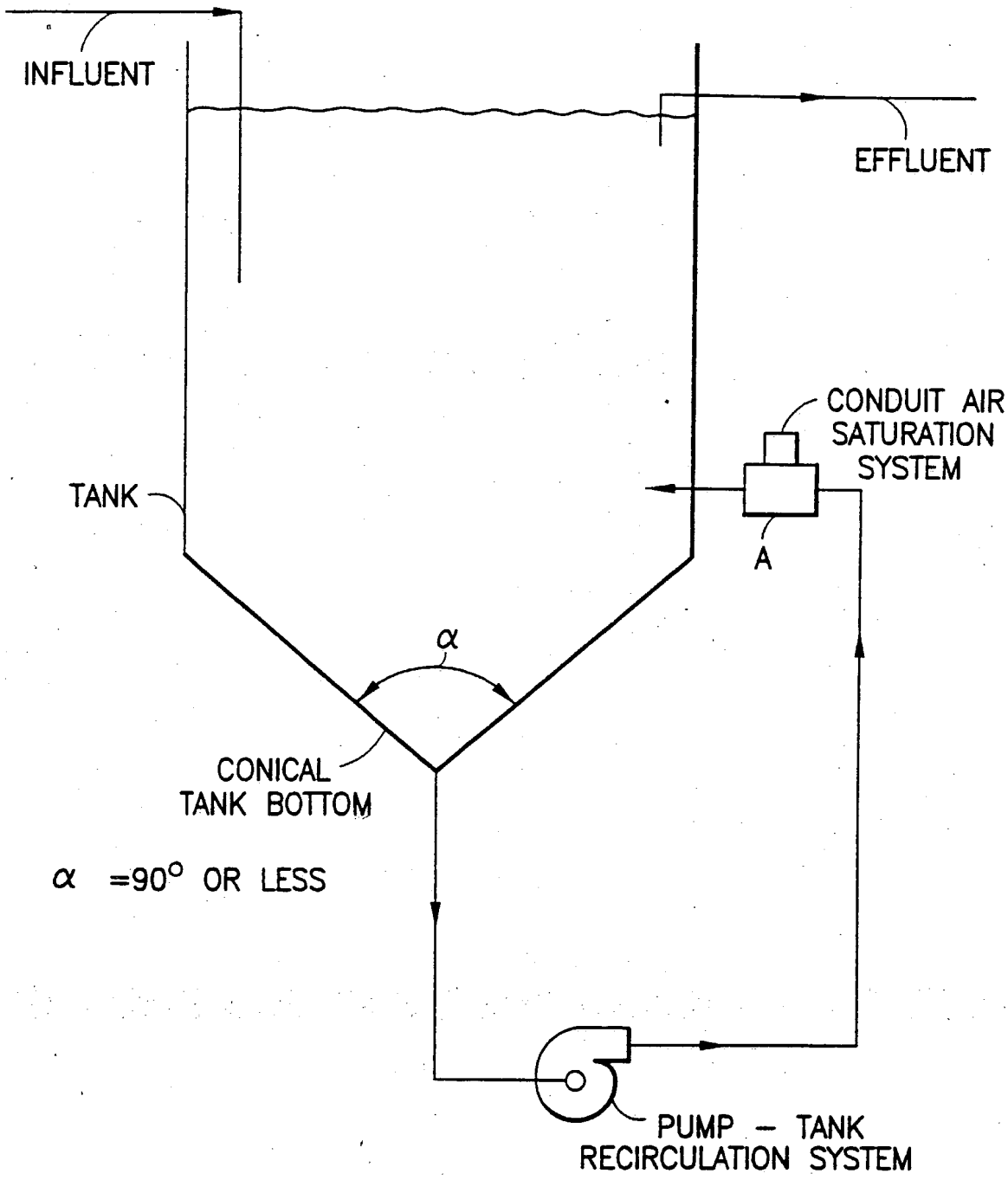
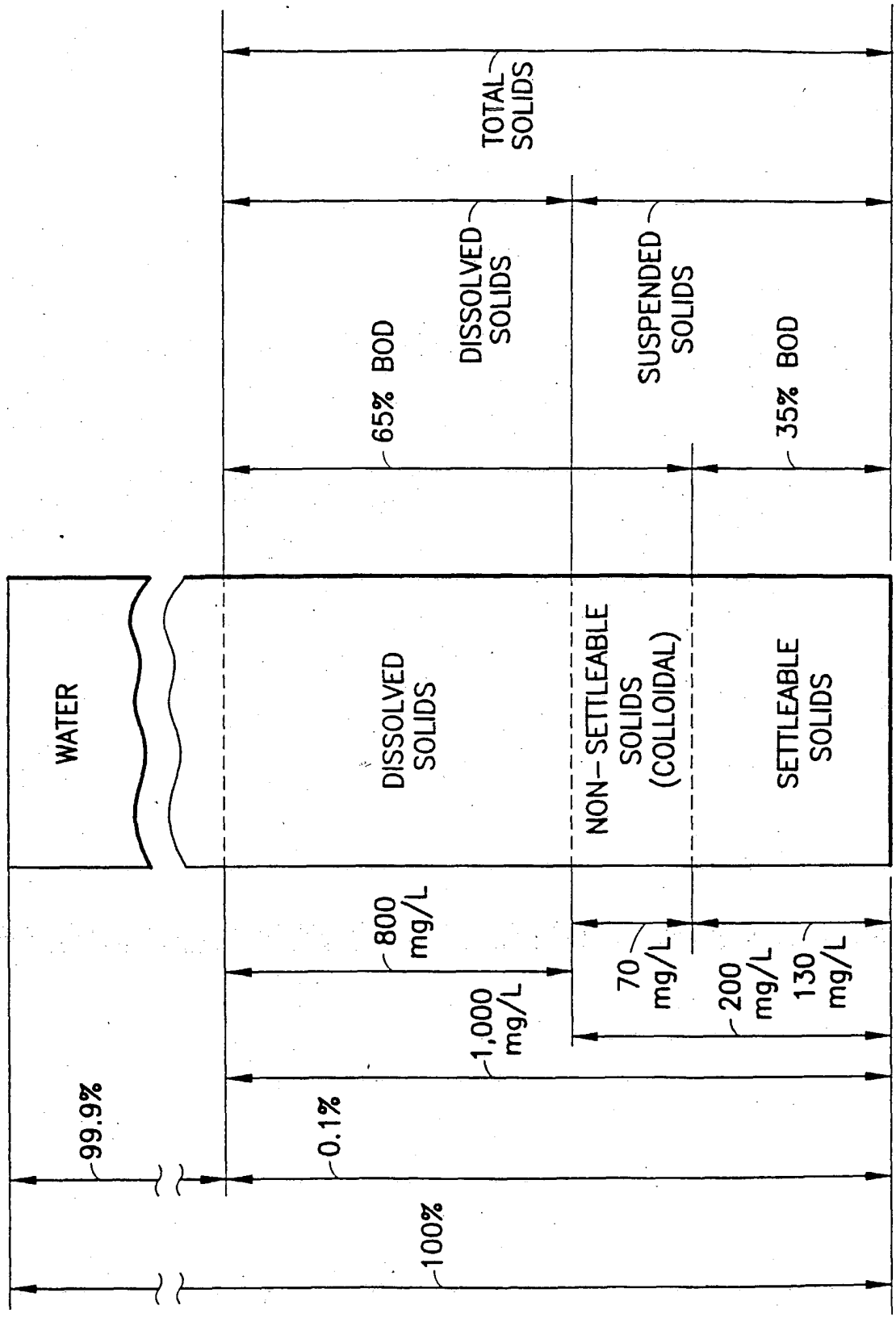
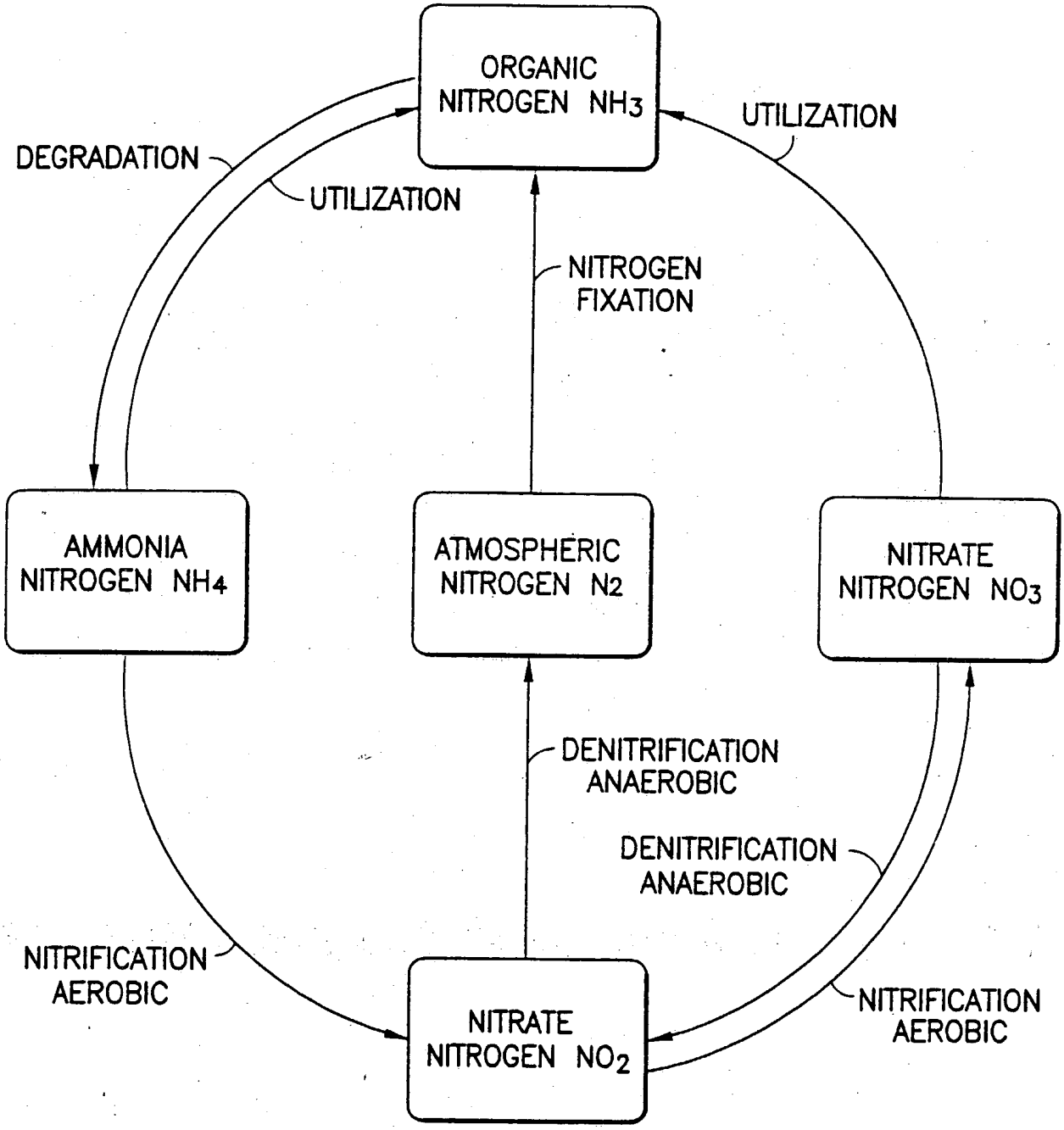

INFLUENT
EFFLUENT
CONDUIT AIR SATURATION SYSTEM
TANK
A
α
CONICAL TANK BOTTOM
α =90° OR LESS
PUMP – TANK RECIRCULATION SYSTEM

FIG.12



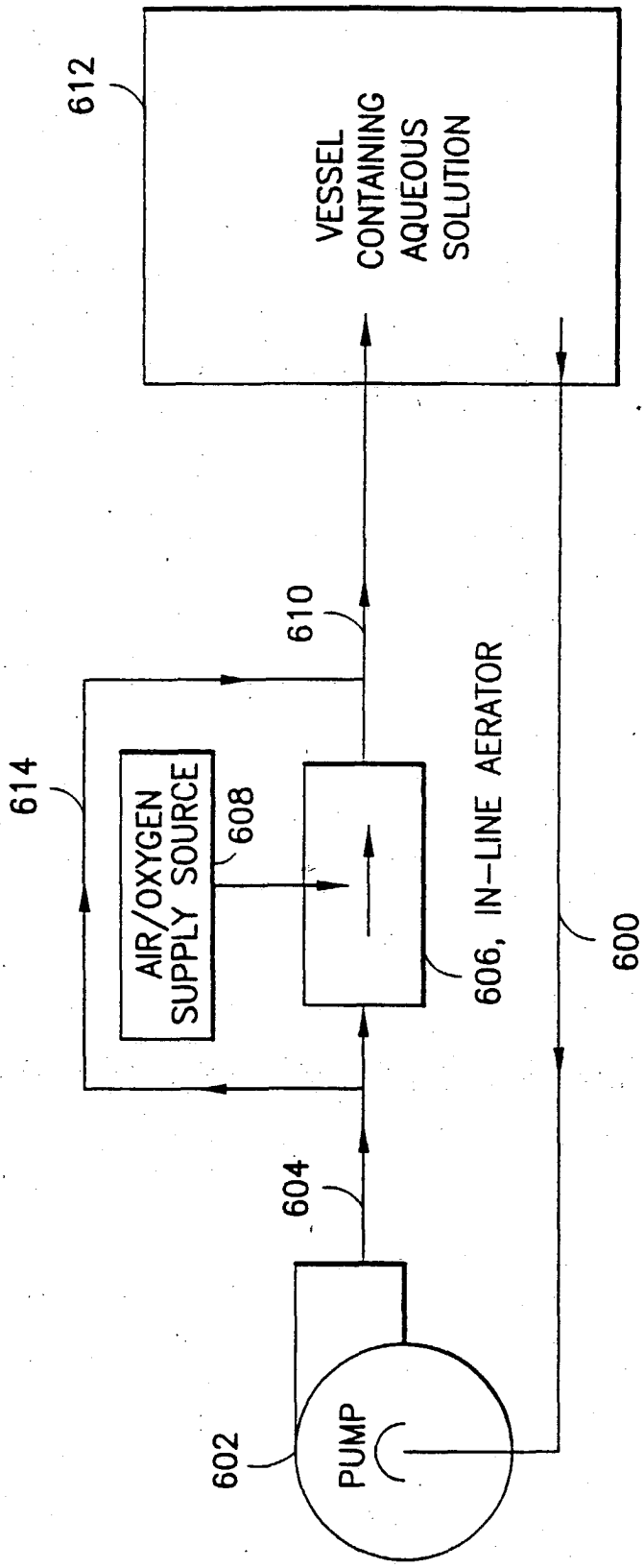

TYPICAL COMPOSITION OF SOLIDS IN RAW INFLUENT OF MUNICIPAL WASTEWATER

FIG. 13




WASTEWATER NITROGEN CYCLE

FIG.14




RE-CIRCULATION AERATION SYSTEM (RCAS)
(WITH OPTIONAL AERATOR BY-PASS)

FIG.15

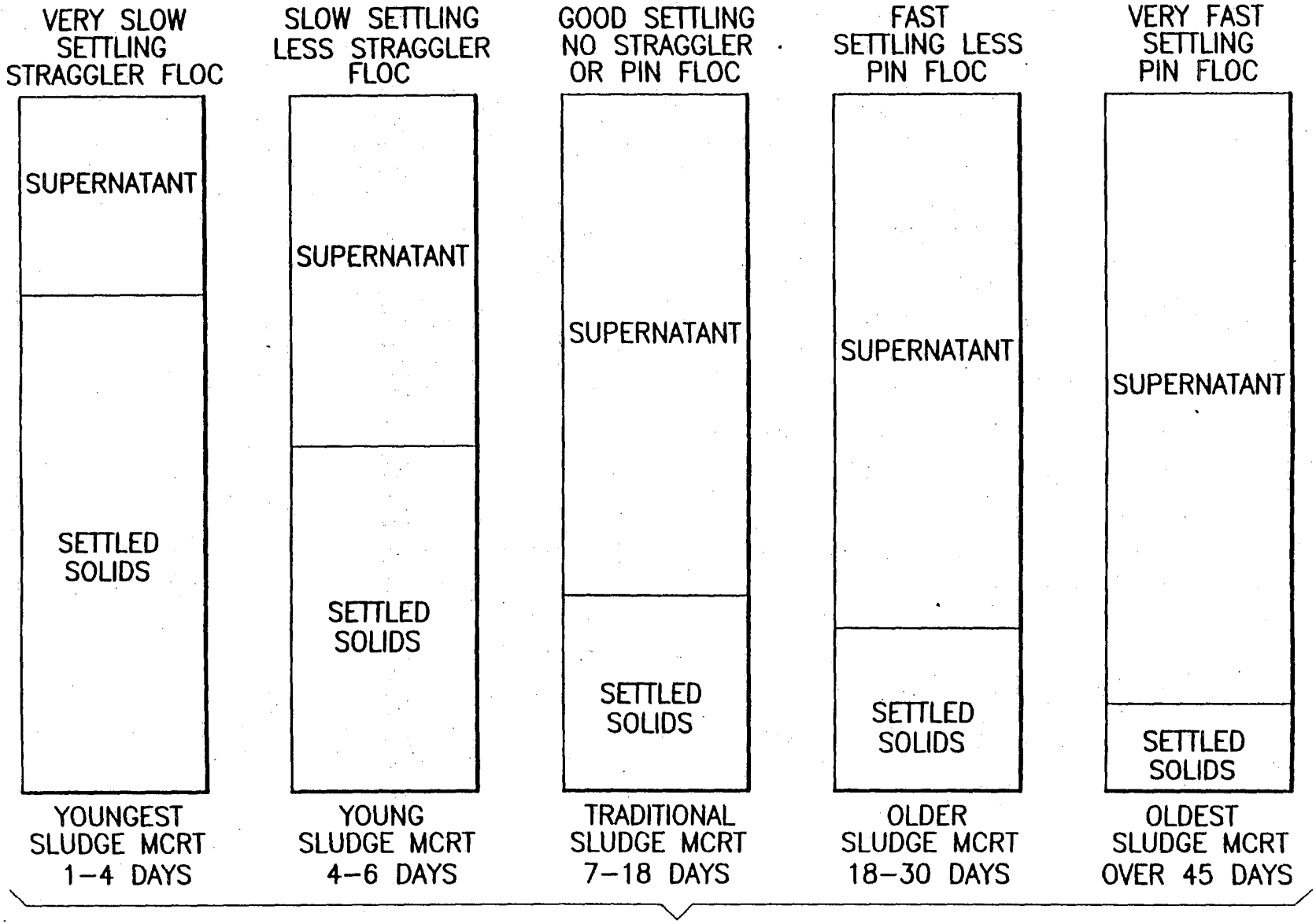



FIG.16 30 MINUTE SOLIDS SETTLING AS RELATED TO MCRT

## DECAY COEFFICIENT

MCRT IS MEAN CELL RESIDENCE TIME

Y IS THE YIELD COEFFICIENT

F/M IS THE FOOD TO MICROORGANISM RATIO

BOD REM EFFCY IS THE BOD REMOVAL EFFICIENCY

$K_d$ IS THE DECAY COEFFICIENT

SOLVING FOR $K_d$

$$K_d = (Y)(F/M)(\text{BOD REM EFFCY}) - \frac{1}{\text{MCRT}}$$

WHERE:

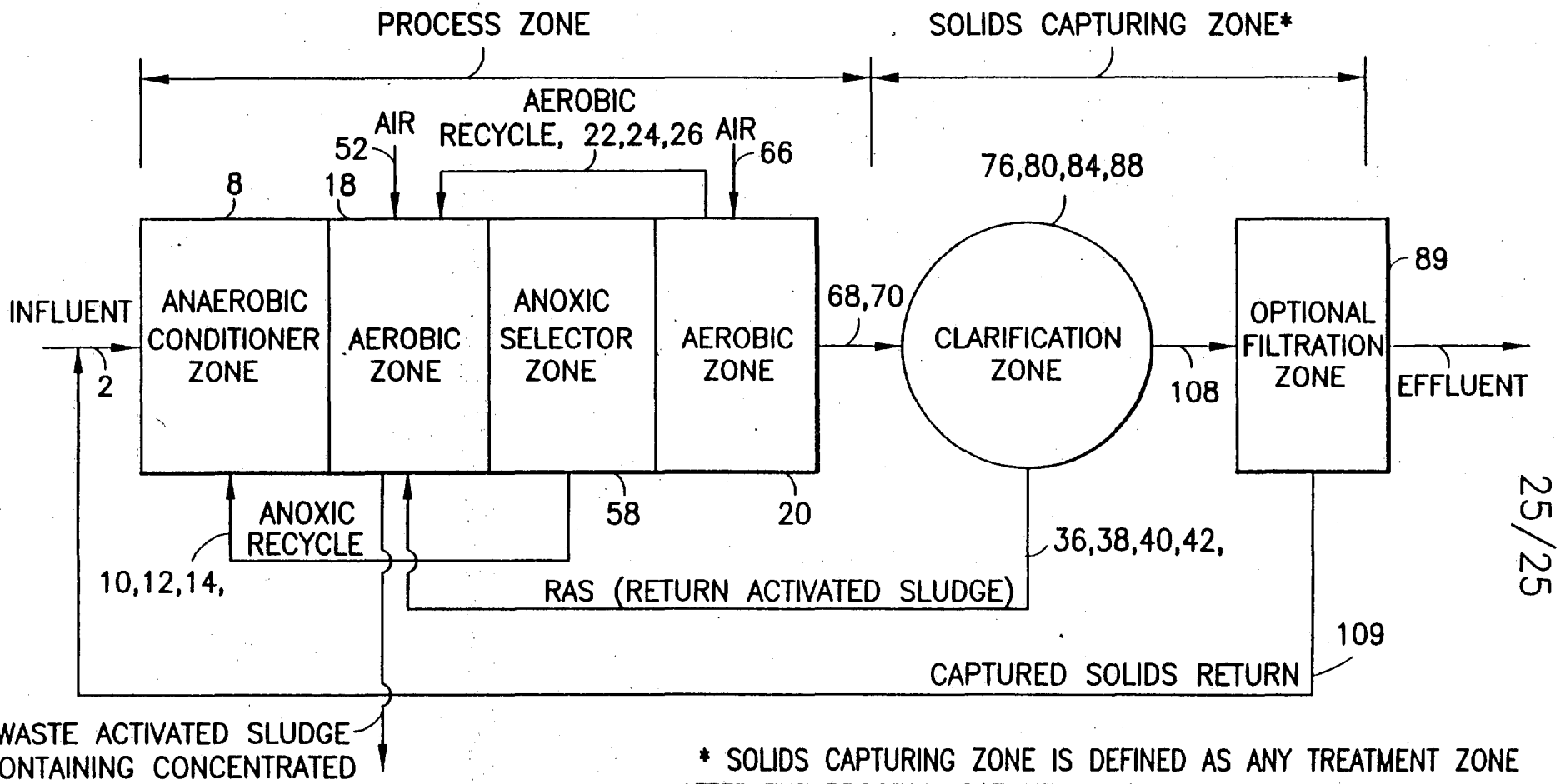
Y = 0.55 lbs OF VSS PRODUCED PER lb BOD REMOVED

$$F/M = \frac{\text{lbs OF BOD APPLIED PER DAY}}{\text{lbs OF VSS IN INVENTORY}}$$

BOD REM EFFCY = % BOD REMOVED IN THE PROCESS AS A DECIMAL

$$\text{MCRT} = \frac{\text{lbs MLVSS IN AERATION SYSTEM}}{\text{lbs MLVSS LEAVING AERATION SYSTEM}}$$

FIG.17




* SOLIDS CAPTURING ZONE IS DEFINED AS ANY TREATMENT ZONE AFTER THE PROCESSING ZONE WHICH ACTS AS A SOLIDS CAPTURING ZONE WHICH INCLUDES BUT ES NOT LIMITED TO CLARIFICATIONS AND FILTRATION STRUCTURES AND OPTIONAL TERTIARY TREATMENT SYSTEMS THAT FURTHER CAPTURES ORGANIC MATTER AND RETURNS THAT ORGANIC MATTER TO THE SYSTEM FOR CONTINUED SOLIDS DIGESTION.

PROCESS FOR BIOLOGICAL WASTEWATER TREATMENT THAT PROVIDES ENHANCED SOLIDS REDUCTION ITH REMOVAL OF BOD, NITROGEN, AND PHOSPHOROUS

FIG.18